PATENT SPECIFICATION

1,042,465

DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in and relating to Fluid Guiding Arrangements for Producing Turbulent Flow in a Tubular Body.

We, INSTITUT FÜR SCHIENENFAHRZEUGE, of 44, Rudower - Chaussee, Berlin - Adlershof, Germany, a Corporation organised under the laws of Eastern Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to fluid guiding arrangements having means for producing a turbulent flow in a tubular body traversed by a fluid medium. Such an arrangement may be a tubular heat exchange device.

It is already known to dispose in the interior of the tubes of heat exchange devices insert elements the purpose of which is to effect a whirling of the medium flowing therethrough, and hence increase the coefficient of heat transfer of the tubes. For this purpose use has already been made of insert elements of the most diverse shapes and cross-sections. Thus, for example, twisted bands or helically bent wires have been disposed inside the tubes. Since however in consequence of the irregular contact between, in particular, the edges of the twisted bands and the inner walls of the tubes poor conduction of heat is produced between the insert elements and the tubes, the heat transfer surface is not fully utilized in such arrangements and an accurately determinable heat transfer cannot be ensured with heat exchange devices equipped in this manner.

Other known heat exchange devices consist of tubes into which one or more straight ribs forming a determined angle with one another are inserted. This arrangement, it is true, provides the advantage that it has only slight influence on the flow resistance of such heat exchange devices, but the Reynold's number is varied in a manner detrimental to the transfer of heat. In addition, through the provision of these ribs the resulting boundary layer of the medium flowing through the tubes, constituting an extremely restricting influence on the transfer of heat, is enlarged.

In addition, tubular heat exchange devices are known the insert elements of which are formed by sheet metal strips, from which rectangular tongues formed by incisions are bent out to project alternatively from opposite sides of the strips. These tongues, provided at determined intervals, hinder the medium in its straight flow through the tubes, so that an eddying of the core zone of the flow of the medium is thereby achieved. The boundary layer forming on the inner wall of the tube however is retained, or is included in the eddying only to a very small extent. The transfer of heat can thus be improved by the provision of such sheet metal strips only to an insignificant extent as compared with tubes without such strips.

The present invention aims at providing a fluid guiding arrangement having means for producing a turbulent flow in a hollow body traversed by a fluid medium, preferably a tubular body of a tubular heat exchange device, whereby, compared with previously known devices, a still more intense flow on to the walls of the hollow body and a destruction of the boundary layer, an increase of the transfer effect, and a reduction of the resistance to flow is achieved.

The present invention consists in a fluid guiding arrangement having means for producing a turbulent flow in a tubular body traversed by a fluid medium, the arrangement comprising an insert element which is dis-

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posed in the hollow body and which is formed by a sheet metal strip having tongues bent out of the sheet metal to project alternately from opposite sides thereof, the tongues being disposed so as to follow one another closely part of their cut edges having a shape conforming to that of the wall of the hollow body and lying in contact with the said wall.

In order to make the invention clearly understood, reference will now be made to the accompanying drawings which are given by way of example and in which:—

Fig. 1 shows a cross-section through a tube of a heat exchange apparatus constructed according to the invention;

Fig. 2 is a horizontal longitudinal section through the tube shown in Fig. 1;

Fig. 3 is an elevation of a sheet metal strip insert element;

Fig. 4 is a graphic representation of the heat flow rate of an oil heat exchanger incorporating the arrangement of the invention, with different oil throughputs, a constant cooling water inlet temperature, and a constant water throughput;

Fig. 5 shows the cross-section of a water cooled oil heat exchange apparatus tube which is equipped with an insert element provided with divided tongues;

Fig. 6 is a horizontal longitudinal section through the tube illustrated in Fig. 5;

Fig. 7 is an elevation of an insert element having divided tongues, as accommodated in the heat exchange apparatus shown in Figs. 5 and 6;

Fig. 8 is a diagrammatic representation of the paths of flow inside a tube in a heat exchange apparatus equipped as illustrated in Fig. 6;

Fig. 9 shows in elevation the diagrammatically represented paths of flow shown in Fig. 8;

Fig. 10 shows diagrammatically the paths of flow inside a tube equipped in the manner shown in Fig. 6, when the direction of flow is opposite to that shown in Figs. 8 and 9; and

Fig. 11 shows in elevation the diagrammatically represented path of flow shown in Fig. 10.

A sheet metal strip 2 is inserted in a tube 1 of a heat exchange apparatus. Tongues 4 are partly cut out of the sheet metal strip 2 by means of incisions 3 and alternate tongues are bent out of the sheet metal strip 2 to project from opposite sides thereof. The incisions 3 are so shaped that the cut edges 5 of the tongues 4 produced by them are adapted to the inner wall 7 of the tube. The acute angle 8 enclosed by the tongues 4 and the sheet metal strips 2, is determined during manufacture so that when the strip is inserted into the tube the cut edges 5 of the tongues 4 are pressed against the inner wall 7 of the tube. The width of the sheet metal strip 2 corresponds to the inside diameter of the tube 1.

The tube 1 is traversed by a fluid medium, for example oil, indicated diagrammatically by the arrow 9 in Fig. 2, the flow being in the direction of said arrow. The medium impinges on the sides of the tongues 4 and is conducted by them on to the inner wall 7 of the tube. Part of the medium flows through the gaps between the tube and the top and bottom of the tongues with increased speed of flow at the point at which the cross-section of the tube 1 is reduced by the tongues 4, whereby the boundary layer of the medium forming on the inner wall 7 of the tube is practically completely destroyed. Behind the tongues 4, viewed in the direction of flow, known eddies (not illustrated in the drawing) form, which have been investigated in flow technology and which in this region also effect a destruction of the boundary layer of the medium. The other part of the medium escapes through the openings 6 and is thus also diverted from its original path. Through the provision of the sheet metal strip 2, with the tongues 4 in the tube 1, a completely turbulent flow and also practically complete destruction of the boundary layer of the medium flowing through the tube 1, which boundary layer forms on the inner wall tube 7 of the tube and acts as insulating layer, are achieved. Thus practically complete utilization of the entire current of medium for the transfer of heat to the tube 1 is possible.

The influence of the direction of flow of the medium inside the tube on the transfer of heat in a heat exchange apparatus can be seen from the diagram shown in Fig. 4. This diagram shows the heat flow rate Q plotted against temperature t oil of the medium in an oil heat exchanger incorporating the invention with different oil throughputs, constant cooling water inlet temperature, and constant water throughput. The characteristic curves 10 shown as broken lines represent the heat flow rates with a flow of the medium through the tube 1 in the direction of the arrow 9, while the characteristic curves 11 shown in solid lines show these values with the flow in the opposite direction, that is to say in the direction of the arrow 12 (see also Fig. 2). The characteristic curves 10 and 11 show clearly that the heat flow rates of the oil heat exchanger are considerably higher (about 25%) in the case of the flow of the medium in the direction of the arrow 9 than with a flow path in the opposite direction, the characteristic curves 10 and 11 having been determined by experiments.

The direction of the flow of the medium is consequently of decisive importance to the extremely favourable heat transfer conditions of the heat exchange apparatus according to this exemplified embodiment of the present invention.

According to another embodiment, see Figs. 5 to 11, a sheet metal strip 16 is accommodated in a tube 15, the tongues partly cut out of said strip by incisions 17 being divided, the resulting half-tongues 18 and 19 being bent to project from opposite sides of the sheet metal strip 16 in a manner such that consecutive half tongues project from opposite sides of the strip. Openings 20 are thus formed in the sheet metal strip 16.

The incisions 17 are so shaped that the cut edges formed by them on the half-tongues 18 and 19 are adapted to the inner tube wall 22. In addition, through the correspondingly determined size of the angle 23 enclosed by the sheet metal strip 16 and the half tongues 18 and 19, the effect is achieved that the cut edges 21 of the half-tongues 18 and 19 are pressed against the inner tube wall 22. The width of the sheet metal strip 16 also corresponds in this arrangement to the inside diameter of the tube 15.

The tube 15 is traversed by a fluid medium, represented diagrammatically by flow lines 24 in a main direction of flow 25 (Figs. 8 and 9). Two main streams 26 and 27 are formed in a plane at right-angles to the plane of the sheet metal strip 16 and two main streams one of which is 28, in a plane parallel to the plane of the sheet metal strip 16, all of which have an approximately sinusoidal path.

In the illustration given in Fig. 8 it can be seen that the two main streams 26 and 27 consist substantially of two sinusoidal curve which, referred to the plane of the sheet metal strip 16, lie side by side and which have a phase displacement of 180° in relation to one another because of alternate half-tongues 18 and 19 projecting from opposite sides.

The path of the main streams 26 and 27, viewed at right-angles to the direction of flow in the plane of the sheet metal strip 16, is as follows, starting from an aperture 20:— The flow lines 24 situated in the immediate proximity of the front sides of the half-tongues 18 and 19 run approximately parallel to one of the half-tongues. They impinge directly on the tube wall 22 and are deflected by the latter, thus forming a flow parallel to the tube wall 22. These flow lines 24 are then deflected by the main stream 28 flowing through the spaces at the sides of the half-tongues 18 and 19 and which is shown more clearly in Fig. 9. The flow lines 24 then pass through the next aperture 20 in the sheet metal strip 16 at a slight inclination to one of the half-tongues. They are there again deflected by the flow lines 24, so that they run approximately parallel to one of the half-tongues. Thereupon the flow lines 24 again resume the above described flow path.

Fig. 9 shows only the path of the main stream 28 flowing parallel to the sheet metal strip 16. For reasons of clarity the main stream 29 which flows on the other side of the sheet metal strip 16 and which has the same path as the main stream 28 with a phase displacement of 180° thereto, is not shown.

The current lines 24 of the main stream 28 are deflected primarily away from the centre of the tube to alternate sides of the tube wall 22 by the half-tongues encountered by the stream. A part of the flow lines 24 however passes out of this main stream 28 and is deflected into one half of the aperture 20, while the main stream 28 receives a corresponding quantity from the upwardly directed main stream 29 (not illustrated) coming from the other half of the aperture 20. Accordingly, one half of each aperture 20 is fed by the main stream 28 and the other half by the main stream 29.

With the direction 30 shown in Fig. 10 and 11 for the main flow of the medium inside the tube 15, the main streams 31, 32, 33, and 34 run similarly to the main streams 26, 27, 28, and 29 with the main direction of flow 25 shown in Figs. 8 and 9, so that in this case similar conditions occur to those previously described and therefore will not be again described in detail.

With the aid of the flow diagrams illustrated and described it can be seen that through the provision of the arrangement according to the invention in the tubes of a heat exchange device a highly turbulent flow is achieved therein with only a slight increase of the flow resistance. The medium passed through the tubes 1 or 15 is caused by the insert elements to change its direction continually and to flow on to the tube walls, thus preventing to a degree not hitherto achieved the formation of laminar boundary layers on the tube walls. Very much higher coefficients of heat treansfer are thus achieved than with undisturbed parallel flow, so that for example heat exchangers equipped in this manner can be of surprisingly small construction.

In addition, the extremely favourable heat transfer coefficients can be still further increased by a suitable combination of the sheet metal strip 2 or 16 having tongues 4 or half-tongues 18 and 19 with the tube 1 or 15, for example by dip soldering since by this means the transfer of heat through conduction through the soldered connection from the sheet metal 2 or 16 to the tube 1 or 15 is improved.

The application of the principle of the invention is not however restricted solely to the field of heat exchange devices. Since by the arrangement constructed in accordance with the invention extremely good turbulence of a medium conducted through correspondingly equipped tubes of any geometrical shapes is produced, so that a highly turbulent flow is obtained, it can be applied wherever such conditions have to be fulfilled, for

example for mixing liquids in the chemical industry.

In addition, it is possible to apply the arrangement of the invention for preventing the segregation of suspended or dispersed components of a fluid medium conducted through tubes, the fluid medium consisting of substances of different densities, for example colloidal solutions and the like.

WHAT WE CLAIM IS:—

1. A fluid guiding arrangement having means for producing a turbulent flow in a tubular body traversed by a fluid medium, the arrangement comprising an insert element which is disposed in the hollow body and which is formed by a sheet metal strip having tongues bent out of the sheet metal to project alternately from opposite sides thereof, the tongues being disposed so as to follow one another closely part of their cut edges having a shape conforming to that of the wall of the hollow body and lying in contact with the said wall.

2. An arrangement as claimed in Claim 1, wherein the tongues lie resiliently against the wall.

3. An arrangement as claimed in Claim 1 or 2, wherein the tongues are divided and the two adjacent halves of each tongue and consecutive series of half-tongues are bent out of the sheet metal strip to project alternately from opposite sides thereof.

4. An arrangement as claimed in Claim 1 or 2, wherein the tongues are disposed so as to slope in the direction of flow of the medium flowing through the tubular body.

5. An arrangement as claimed in any one of Claims 1 to 4, wherein the sheet metal strip and the cut edges of the tongues or half-tongues are joined to the wall of the tubular body by dip soldering.

6. An arrangement as claimed in any one of Claims 1 to 5, wherein the width of the sheet metal strip corresponds to the inside diameter of the tubular body.

7. Fluid guiding arrangements for producing turbulent flow in a tubular body constructed, arranged and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig1

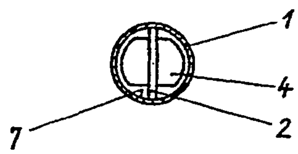


Fig.2

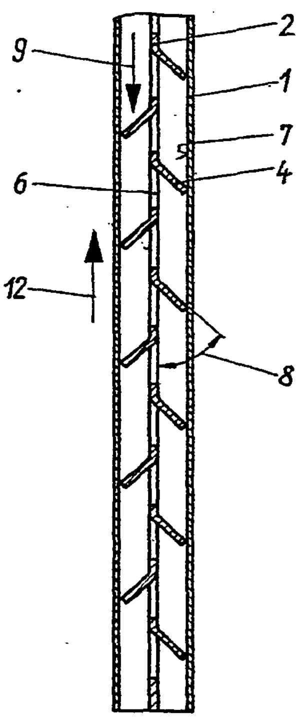


Fig3

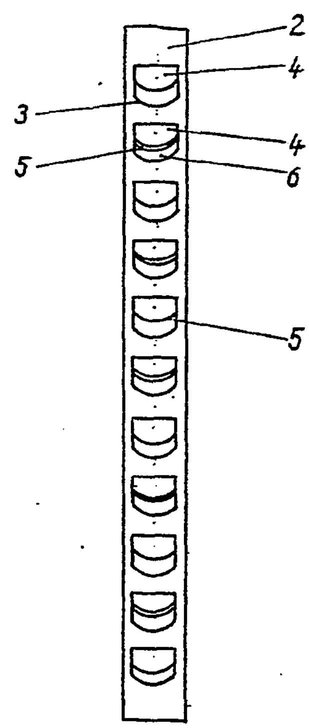
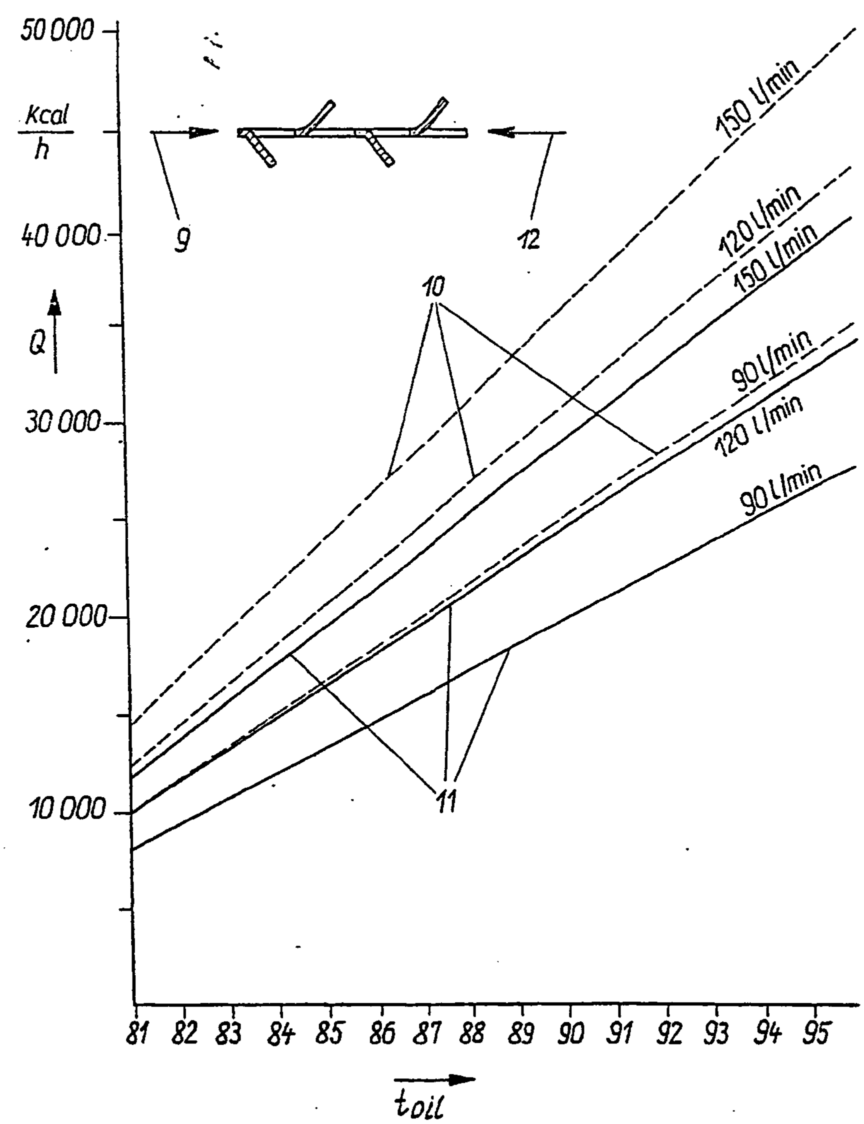


Fig.4



50 000
40 000
30 000
20 000
10 000
Kcal/h
Q
150 l/min
120 l/min
150 l/min
90 l/min
120 l/min
90 l/min
9
12
10
11
81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
t_{oil}

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Sheets 2 & 3

Fig.5

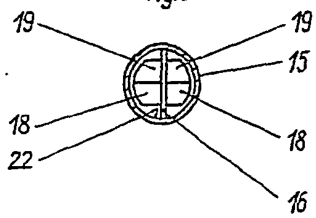


Fig. 6

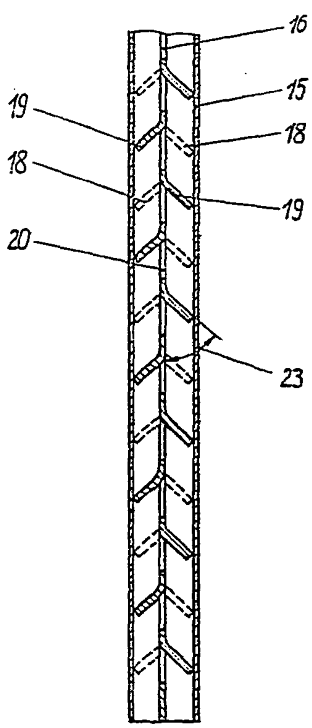


Fig.7

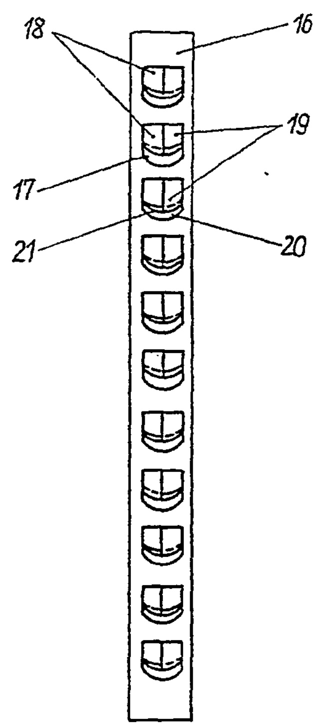


Fig.4

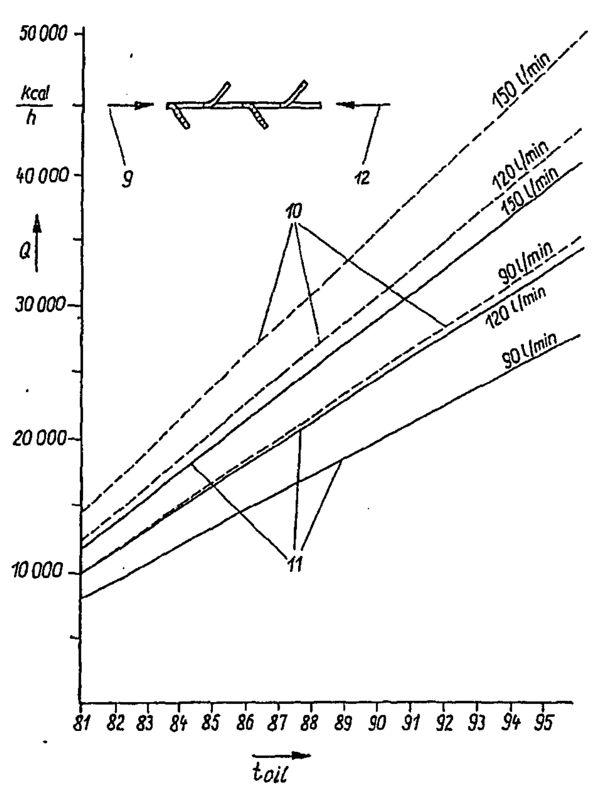


Fig.5

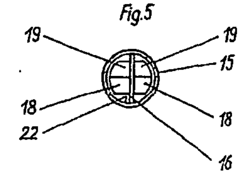


Fig.6

Fig.7

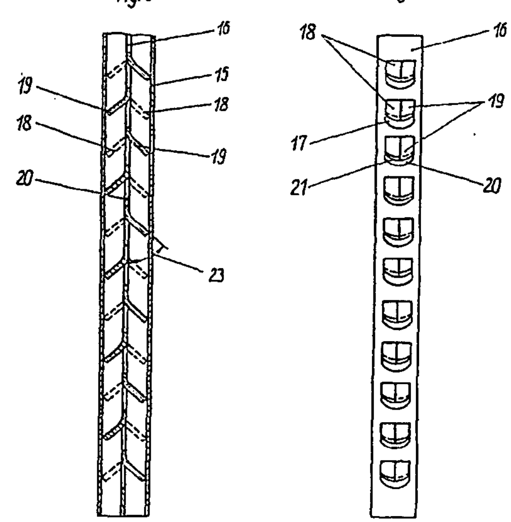


Fig. 9

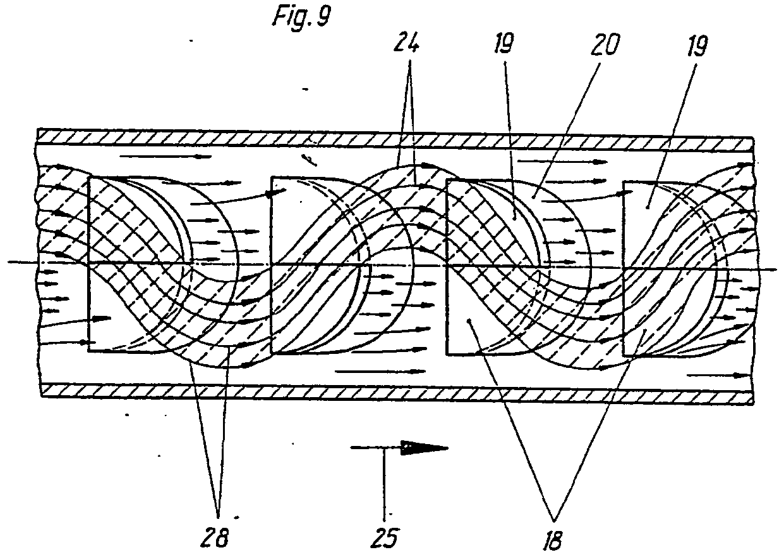
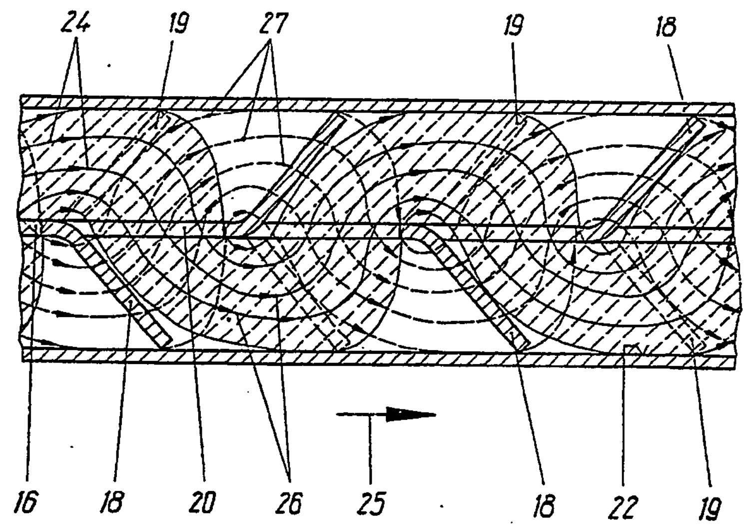


Fig. 8



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Sheets 4 & 5

Fig 11

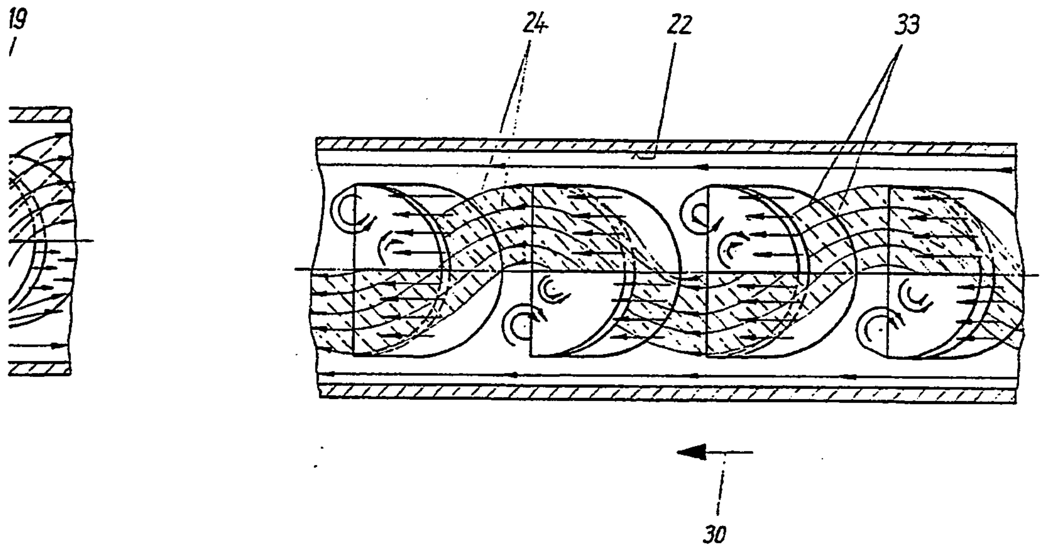
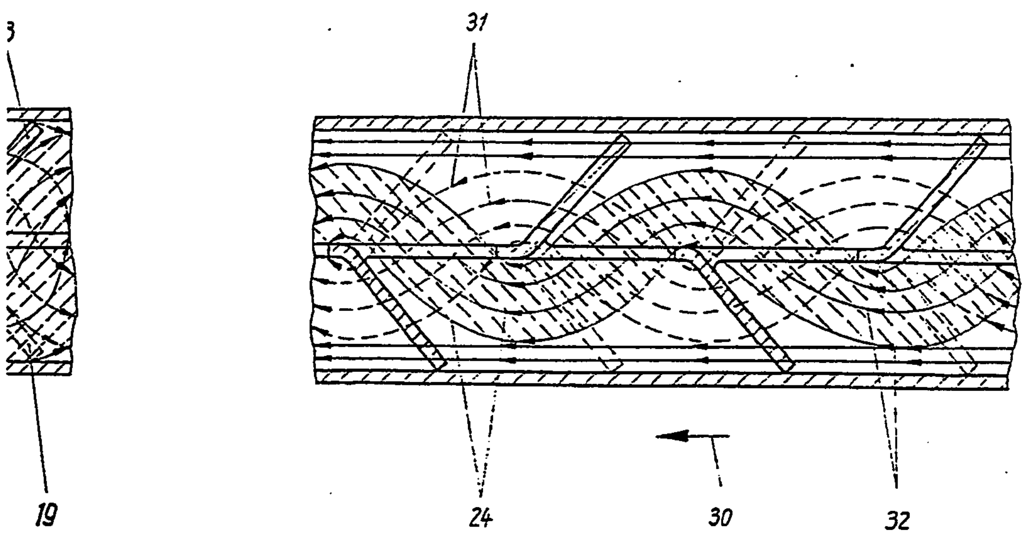


Fig 10



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Sheets 4 & 5

Fig. 9

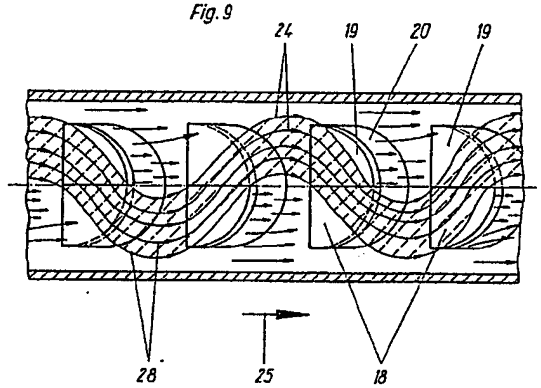

Fig 11

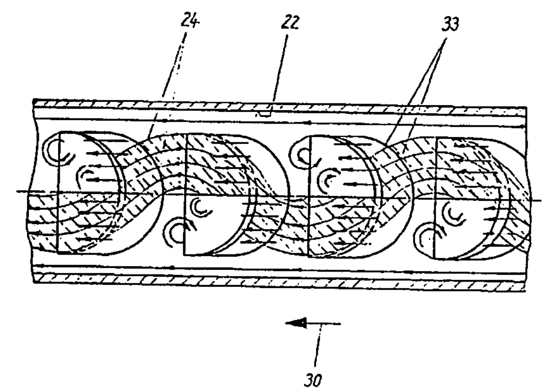

Fig.8

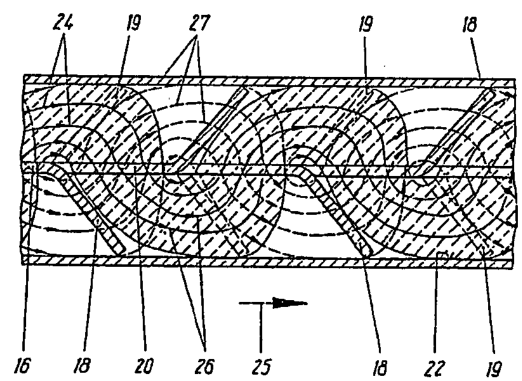

Fig 10